CENTRAL ADVISORY WATER COMMITTEE

Sub-Committee on The Growing Demand for Water

FIRST REPORT

LONDON
HER MAJESTY'S STATIONERY OFFICE
1959
PRICE 1*s.* 3*d.* NET

CENTRAL ADVISORY WATER COMMITTEE

SUB-COMMITTEE ON THE GROWING DEMAND FOR WATER

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DEFINITIONS

Certain expressions used in the report are explained in the text as they occur. For ease of reference they are summarised here:

1. *Mean Water Yield* (paragraphs 25–26 and section 10 of Appendix II). The total flow of water from a catchment area averaged over a long period of years; the sum of the surface run-off and the percolation to aquifers.

2. *Potential Resources* (paragraph 13). The quantity of water which could be made available by the development of all resources that are physically capable of development.

3. *Statistical Area* (paragraph 4). A group of the hydrometric areas used in the Surface Water Year Book. The statistical areas are shown in the map and table in Appendix I.

4. *Survey Supply* (paragraph 14, and section 1 of Appendix II). The quantity of water judged to be available at reasonable cost for the purpose of meeting the foreseeable needs of public water undertakers. The survey supply is thus related to the estimated demand; it is not an expression of the total developable resources and is in no sense a limiting figure.

REPORT TO THE CENTRAL ADVISORY WATER COMMITTEE

I. APPOINTMENT

1. We were appointed by the Central Advisory Water Committee on 31st October, 1955, as a Sub-Committee with the following terms of reference:

> "To consider the extent to which the demand for water for domestic, industrial, agricultural and other purposes is increasing and is likely to increase; to consider the problems involved in meeting these demands, including, in broad terms, the cost; to consider whether there are any substantial economies in the use or cost of water which could be made without reduction in standards of hygiene or in industrial or agricultural efficiency; and to make recommendations."

We now present our first report in which we set out our main conclusions. We hope to continue our work on particular aspects of our terms of reference such as the demand for water for agricultural irrigation and economies in the use of water in industry.

Our report covers England and Wales.

2. Mr. H. F. Cronin, Mr. L. W. F. Millis and Mr. J. D. Peattie accepted invitations to become co-opted members. Mr. Peattie resigned in February, 1957, on his retirement from the Central Electricity Generating Board and was succeeded by Mr. D. Clark. Mr. H. Woolley resigned from the Sub-Committee in February, 1958. We also had the benefit of the advice of assessors appointed by the Ministry of Agriculture, Fisheries and Food, the Board of Trade, the Department of Scientific and Industrial Research and the Ministry of Housing and Local Government.

II. PROCEDURE

3. We have met eight times. The chief part of our task as we see it has been to enquire into the practice and experience of the major statutory water suppliers and water users in England and Wales, for the purpose of preparing a balance sheet of supply and demand for water. This work has been carried out by the Sub-Committee as a whole. The question of economies in the use or cost of water was for convenience remitted to an Economies Group comprising Messrs. Cronin, Hood, Hopthrow, McLellan and Millis, sitting with assessors. We have adopted the recommendations of the Group and these are incorporated in Part IV of the report.

III. ANALYSIS OF SUPPLY AND DEMAND

4. Differences of rainfall, geology and physical structure cause the natural water resources of England and Wales to vary widely from region to region. A survey of resources, if it is to be of value as a guide to available water, must therefore be divided into areas and for this purpose groups of the hydrometric areas used in the Surface Water Year Book* have been adopted as the most convenient unit. The groups are called "statistical areas" in this report; there are 18 of them in England and Wales (map, Appendix I).

* Published annually by H.M. Stationery Office.

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5. For our purposes there are, in broad terms, two categories of water supply and two categories of demand to be satisfied. Supplies are provided by the puhlic water undertakers or ohtained privately; demand is industrial or domestic*. This dual character of both supply and demand led to considerable difficulties in our work, particularly in the field of industrial demand on private sources of supply. The identity of public water undertakers is known, nearly all of them keep records of the quantities of water whioh they supply and the sources from which these are drawn; the statistical information obtained from them was therefore sufficiently accurate and complete for our purpose. Private supplies are much more complex: no complete census of sources of supply exists, some consumers do not keep records of their water usage and some are reluctant to make information availahle. We have thus followed two lines of enquiry, described helow in paragraphs 8–16 (public water undertakers) and 17–21 (water from private sources). Our enquiries of the nationalised industries are described separately in paragraph 22.

Public Water Undertakers

6. All puhlic water undertakers were invited to complete a questionnaire designed to show not only the quantity of water supplied in 1955 hut also, where possihle, the quantity in each year since 1926, the estimated quantity required to satisfy demand in 1965, 1975 and 1985, the amount of non-potable water supplied (if any), the population of the supply area in each year, the estimated expenditure on future capital works, the extent to which waste detection methods are used and other data from which an estimate could he made of the present situation and future trends.

7. Returns covering some 93 per cent. of the population of England and Wales were ohtained for the hase-year of 1955. A numher of small undertakers failed to complete the questionnaire in whole or in part hut the effect was not significant and it was generally possihle to make an appropriate allowance in the estimates, as described in Appendix II. The results are set out in Figure 1 of Appendix II.

Future Demand on Public Water Undertakers

8. Although undertakers were invited to forecast consumption in 1965, 1975 and 1985, the replies gave reasonahly satisfactory coverage only up to 1965 and we decided that detailed comparison could he undertaken only as hetween 1955 and 1965.

9. The questionnaires show that undertakers expect consumption to rise by ahout 23 per cent. during the ten years to 1965. This is an average figure for England and Wales as a whole and includes both metered water (which hroadly represents the industrial demand) and unmetered water (broadly representing domestic demand); some variation from the average appears if individual areas, or metered and unmetered water, are examined separately. Past trends of consumption for seven selected districts have heen plotted in Figures 2 and 3 of Appendix II. Districts of widely different geographical characteristics were chosen for this purpose; the districts are typical of conurhations (Greater London, West Midlands and South-east Lancashire),

* Water for agriculture is included in all four categories. Allowance for it has been made in our estimates, subject to the qualifications in paragraphs 28 to 31.

agricultural areas (East Anglia and Holland and Kesteven), mixed areas (South Essex, excluding parts served by the Metropolitan Water Board) and holiday resorts (Brighton).

10. It will be seen from Figure 3 that during the 30 years or so to 1955 total consumption in the selected districts has been rising at a rate of about 2 per cent. a year, which is slightly below the expected national average of 2·3 per cent. for the 10 years 1955 to 1965, and that since 1944 metered consumption has been rising faster than unmetered. Estimated future consumption was not available in sufficient detail to continue the graphs beyond 1955 but national figures, in terms of gallons per head per day, divided into administrative regions, are given in Figure 4 from which it is clear that the trends established in the selected districts are expected by undertakers to continue in the country as a whole, including the predominance of metered water in the additional consumption.

11. For longer term forecasts we were unable to obtain any reliable data and we decided not to attempt numerical estimates. Our conclusions are given in paragraphs 25–27 and in Part V.

Public Supply

12. Rain is the source of all natural fresh water but only part of the water falling on an area as rain can be made available because practical economics set a limit to, and natural losses such as evaporation and transpiration reduce, the quantity of water that can be exploited. The heavy discharge of rivers occurring during periods of flood is only available to the extent that it can be stored, the remainder running to waste ; moreover a proper flow must be reserved to the river to maintain its physical characteristics, to provide for fish and plant life and the rights of riparian owners and for the dilution of effluents. Water which is not channelled into rivers but runs off direct to the sea cannot be brought into supply, and some of the water that percolates into the ground is also not accessible.

13. The quantity of water which could be made available by the construction of reservoirs, river intakes, boreholes and other engineering works may be termed the *potential resources* of an area. It is this quantity which determines the maximum amount of water that can be put into supply in a given area to satisfy the demand, without regard to cost. It does not include tidal water, large quantities of which are at present used by industry for cooling purposes. In the future the processes of demineralisation and distillation may be further developed to a point where it will be practicable to use more tidal water for both industrial purposes and public supplies, but at the present stage of development the cost is in general greater than that of piping water over long distances.

14. Surveys carried out between 1945 and 1958 by engineers of the Ministry of Housing and Local Government with the co-operation of water undertakers in England and Wales have shown that, at the time when they were made, supplies could be developed to meet the demand of the water undertakers in England and in the industrial areas of Wales for the 20 to 30 years of the foreseeable future. The quantity of water for which provision is made in these surveys is the supply figure with which we are mainly concerned in this report and may be termed the *survey supply*. Further information is given in Appendix II ; all that need be said here is that the estimates of survey

supply shown in column 6 of Figure 1 are essentially the work of practical water engineers concerned with public supply who set out to see whether future needs could be met with an adequate margin of safety. The surveys do not purport to assess potential resources, irrespective of cost, nor do they take into account private sources of supply.

15. Changed circumstances in some areas since the dates of the surveys have made it necessary to develop greater resources than the surveys envisaged and in some cases to defer the development of the sources recommended and to substitute others for them. Nevertheless, the information gained from the surveys provides, in our opinion, the only practical assessment that can be made of supply at present and, since we believe that they tend to under-estimate rather than over-estimate the water available at reasonable cost, we adopt the results with some confidence.

Quality of Public Supplies for Industry

16. Industry uses water ranging in quality from polluted tidal water to distilled water. Potability is not necessarily a criterion of suitability, because mineral constituents in potable water which are wholesome for human consumption may be harmful to industrial plant and processes. Treatment of potable water by industry for its special uses is often essential and may be expensive or technically difficult. About 30 undertakers in England and Wales supply untreated or partially treated water for industry and it has been suggested that this practice might be extended. Whether such a separate supply can be provided economically depends upon a variety of local circumstances such as length of mains, availability of alternative private supplies and the relative cost of treated and untreated water from water undertakers. While we feel unable to make any general recommendation, we think that the possibility merits exploration in suitable localities by both water undertakers and industry.

Water from Private Sources

Demand

17. Preliminary consideration of the problem of industrial water from private sources of supply soon disclosed an intricate situation. Many industrialists in all parts of the country take their supplies directly from such sources as wells, river intakes and canals and we decided that to obtain particulars of all these sources would be an immense task that would probably not be justified by the results. Some form of statistical sampling was therefore required.

18. On our behalf the Federation of British Industries approached the trade associations of six major industries which, together with the nationalised industries, were believed to account for a substantial part of the industrial demand for water. The industries selected were brewing, chemicals, iron and steel, leather, paper-making and textiles. Questionnaires were circulated to members of the trade associations and some 1,300 were returned completed. Particulars were given of the annual intake of water (including cooling water), the sources from which it was obtained, the method of disposal of effluent and, in some cases, estimates of demand in 1965.

19. Apart from the nationalised industries, only two industries attempted an estimate of their 1965 demand. The somewhat meagre information

available points to an increase of between 10 per cent. and 32 per cent. from 1955 to 1965 and as a working measure we have assumed a general increase in all areas of 25 per cent. This figure accords with the expected rise of 23 per cent. in the demand on water undertakers (paragraph 9).

20. Although a large number of returns was received the figures of total demand for water which have been calculated from them must be regarded as no more than a guide, not to be compared in reliability with the figures returned by public water undertakers. Sampling by industry inevitably produces an uneven distribution of information because interest is focused on certain heavily industrialised areas, while in some of the selected industries the coverage of the replies to the questionnaire was not complete and some important water-using industries were not included at all. The effect of these deficiencies is hard to assess and we publish the returns (with some adjustments—see section 7 of Appendix II) in Figure 5 of Appendix II with full knowledge of their limitations. We consider however that these deficiencies are to some extent offset by the adoption of conservative estimates of supply, as described in paragraph 21.

Supply

21. For the same reasons we were unable to make a scientific assessment of the private supplies likely to be available to meet the additional demand in 1965, assumed (paragraph 19) to be some 25 per cent. greater than the 1955 demand. An overall increase of 25 per cent. could almost certainly be obtained but a similar increase in every area is more doubtful; some areas could yield more, others perhaps less. We have therefore decided that, in estimating the supply and demand position in 1965 (see paragraphs 23–24), the only safe course is to suppose that the 1955 supply from private sources will *not* be augmented before 1965, although there is little doubt that more water could readily be found in most areas.

Nationalised Industries

22. The nationalised industries—electricity, coal, gas and transport—also provided particulars of demand in 1955 and, in most cases, estimates for 1965. Apart from water for cooling, the requirements of these industries are not great. The demand for cooling water is immense; the Central Electricity Generating Board alone expects to require some 10 thousand million gallons a day for cooling in 1965, or more than twice the total demand by all other users. However, only a small fraction of this great quantity is consumed —that is, evaporated or otherwise lost—and if the gross amount were included in the calculation of total demand the result would be seriously misleading; moreover, a high proportion is sea or estuarine water. Cooling water in the nationalised industries has therefore been excluded from our estimates but water used for purposes other than cooling, together with an allowance for the *net* cooling requirements (i.e. the water actually evaporated) of the Central Electricity Generating Board has been included with the industrial figures in Figure 5 of Appendix II.

Supply and Demand in 1965

23. Combined estimates of the public water undertakers, the six industries and the nationalised industries, for both supply and demand in 1965, are

given in Figure 6 of Appendix II. As explained above, corrections have been made for the incomplete nature of the information at our disposal and, drawing on experience gained by the Surface Water Survey of the Ministry of Housing and Local Government in a recent hydrological survey of Wales, a further allowance has been introduced to take into account the extent to which water is re-used. Re-use is discussed in Appendix II, section 9. It is clear that a large amount of water is used more than once in its passage to the sea. Water discharged to a river as effluent is often abstracted lower down the river and used again, so that the net quantity of water required to satisfy the demands of all consumers is less than the total quantity used by them. We have assumed that the net requirement is 80 per cent. of the gross demand, a figure which we consider safe because it is unlikely to be exceeded in any statistical area and is almost certainly larger than necessary in most of them.

24. It will be seen from Figure 6 that the estimated supply exceeds the net demand in 1965 in all areas. Bearing in mind the allowances made for possible errors we conclude that, subject to what is said about irrigation in paragraphs 28–31, there need be no overall shortage of water in 1965 apart from purely local difficulties.

Supply and Demand After 1965

25. Because of the difficulty of predicting trends beyond 1965, forecasts must be in increasingly general terms and based on doubtful assumptions and we have not thought it wise to attempt numerical estimates of either supply or demand. On the supply side however we have been able to compute very approximately the total flow of water from each area which, although it does not represent the quantity that it would be physically possible to bring into supply (the potential resources defined in paragraph 13), does indicate the presence of large reserves. Further information about the total flow—called in this report the *mean water yield*—is given in the following paragraphs and a note on the method of computing it appears in Appendix II, section 10.

26. The mean water yield is the total flow of water from an area averaged over a long period of years. The yield will, of course, be less in dry years than in wet years, much higher in winter than in summer and very small at the end of a protracted period of drought. Moreover it is not possible to harness the whole amount, even in areas used exclusively as gathering grounds for water supplies. The mean yield therefore does not afford a ready means of assessing the potential resources that can be developed and maintained at all times and supplied to consumers at a constant daily rate. On the other hand it does provide a first step in comparing the resources of one area with another. Referring to Appendix II, Figure 7, it will be seen how widely the areas differ from each other both in mean yield and in the percentage of the yield expected to be used in 1965. In some parts a development of over 35 per cent. is visualised, while in England and Wales as a whole the proportion is only 11 per cent. This leads us to believe that further development is possible in most areas and that in a few of them there is scope for extensive development. Where development is already high assistance could be given from the underdeveloped areas, as indeed now happens for example in the Trent statistical area where Birmingham draws large supplies from Wales.

27. The Ministry of Housing and Local Government co-ordinates the needs and plans of public water undertakers and no sources can be exploited by them unless they are authorised by an Order of the Minister or by Private Act. With the exception of areas where abstraction of underground water is controlled*, the Minister has no corresponding function in relation to water obtained from sources other than the public undertakers nor has he any standard practice for securing reliable information about supplies and it is clear that at least in some areas the problem of water requirements, both public and private, needs to be looked at as a whole. The only satisfactory way of doing this appears to be by detailed hydrological surveys. Such surveys would involve comprehensive examination in each river basin of rainfall and run-off, public and private sources of supply, effluent discharges, re-use of water and potential storage sites, and if carried out over the whole country would involve a long and heavy programme of work in collecting and processing returns from an enormous number of industrial and other users of water. We are reluctant to impose on water users the labour of compiling returns until the value of such surveys has been tested; nevertheless we consider the time has come when a start should be made in areas where the expected surplus of survey supply over demand in 1965 is lowest, the interest and help of all concerned being obtained from the outset so that all aspects of water demand and supply may be covered. Thereafter the desirability of extending the surveys to other areas could be considered in the light of results obtained from the areas first selected.

Irrigation

28. No allowance has been made in our estimates for water for agricultural irrigation. Estimates of demand for this purpose are largely speculative because irrigation is still in its infancy in this country and it is difficult to say to what extent the farming industry will develop irrigation methods on land which has no immediate access to cheap water. It is clear, however, that the potential demand is very great, so great in many areas that the survey supply would be hopelessly inadequate. On the basis of work done at Rothamsted Experimental Station it has been estimated that, in relation to the full transpiration rate and the attainment of maximum plant growth, there is a deficiency of rain in more than five years out of ten south of the line Humber–Severn and a deficiency in nine years out of ten in Essex, Suffolk and Kent. The magnitude of the deficiency varies from year to year and place to place, with theoretical values ranging from 1″ or less in the wettest year to 12″ in the driest year. The irrigation applied to meet this deficiency will be less than these values according to soil moisture retention conditions and plant rooting characteristics, and in practice quantities exceeding 6″ may only rarely be applied by irrigation. Almost all the water used in irrigation is evaporated or transpired in plant growth and cannot be re-used.

29. As an indication of a possible upper limit of irrigation water needs, if all crops likely to benefit from irrigation south of the line Humber–Severn were fully irrigated, the daily peak rate of consumption during the irrigation season might be of the order of 8,000 million gallons in very dry years. We have been informed that at the present stage of irrigation development the

* Under Section 14 of the Water Act, 1945. The controlled areas are approximately those of the principal aquifers, i.e., the Chalk in south and east England and the Bunter Sandstone in the Midlands.

peak daily water demand might be of the order of 90* million gallons in a very dry year, and that the 1965 peak demand based on the past rate of increase might be of the order of 240* million gallons a day in dry years.

30. The demand for irrigation water in certain areas could far exceed the demand made by industrial and domestic users combined. Although hydrologically the irrigation demand could possibly be met in some places by the particular development of water resources, financially such development may be impracticable. In practice the point will be reached where it is necessary to balance the benefits obtainable from irrigation against the cost of providing the additional water.

31. With modern pumps large quantities of water can be lifted from rivers in a short time and an immediate problem is developing in a few distriots where the rate of abstraotion by riparian land owners is causing embarrassment to river boards, water undertakers and others. We are studying the problems involved, including the possibility of some form of control over the abstraction of surface water analogous to the existing protection of underground water provided by section 14 of the Water Act, 1945, and we hope to make recommendations in our next report.

Current and Future Schemes to Meet the Future Demand and the Cost of such Schemes

New Capital Works

32. Particulars of new works under construction or proposed were given by public water undertakers. Plans are being made by them for a further yield of about 1,000 million gallons a day from the following sources:—

River intakes...	310	m.g.d.
Reservoirs	400	„
Underground sources	275	„
Total	985	„

Approximately 85 per cent. (over 800 m.g.d.) of the construction is scheduled for completion by 1965. 800 million gallons a day is approximately 40 per cent. of the quantity of water distributed by water undertakers in 1955 and would amply cover the average expected rise in the demand on them—23 per cent.—to 1965. Some of these schemes have yet to be referred to or approved by the Minister of Housing and Local Government but we consider that the figures are sufficient to establish that in England and Wales as a whole steps are being taken to safeguard future public supplies (which include an increasing element of industrial consumption), *provided that the necessary statutory powers and capital resources are forthcoming.*

Cost

33. Information provided by the Central Statistical Office or contained in the reports of the Ministry of Housing and Local Government, together with data supplied by water undertakers, permits a tentative estimate to be made of the cost of works needed to meet the future demand on the undertakers. No corresponding information is available for works needed

* These figures were supplied by the Ministry of Agriculture, Fisheries and Food, but were received too late to be taken into account in our estimates.

to expand private sources of supply, but costs are likely to be proportionately much lower than in the water industry itself because private sources are nearly always local and do not in general involve extensive works such as large reservoirs and long pipelines, although some allowance must be made for the cost of any treatment that may be necessary.

34. An important factor in the rate at which capital works can be carried out is governmental policy in the matter of capital investment. The effect of the control of expenditure on an essential service such as water has been comparatively mild but some schemes have been postponed or scaled down on grounds of economy and such schemes can be expected to swell the rate of expenditure when restraints are lifted.

35. The evidence we have been able to gather suggests that capital expenditure on public water supply is now of the order of £30 million a year, with a tendency to rise which may gain momentum as the economic climate improves. The following table shows the approximate growth of capital (England and Wales only) during the years 1948 to 1956. In money terms investment rose steeply in the immediate post-war years as supplies of labour and materials improved and more slowly from 1953 to 1956, the last year for which figures are available. The last column of the table, which is expressed in terms of the £ in 1956, suggests that the actual rate of investment has remained fairly steady at about £30 million since 1950.

Capital Expenditure (£ million)

Year	*Actual*	*Adjusted to the value of the £ in 1956*
1948	13	18
1949	18	25
1950	20	28
1951	24	29
1952	27	29
1953	29	32
1954	28	31
1955	30	31
1956	32	32

36. The value of works which the water undertakers are planning to carry out during the years 1955 to 1965 was returned as £300 million. Taking into account the arrears of work to be done and the urgent need for certain schemes, particularly in rural areas, it seems probable that if restraints were wholly removed the annual investment would run for a time at a figure approaching £35 million a year at present-day costs. Expenditure will also tend to rise because new sources will be more difficult to develop than those used in earlier schemes and water will have to be carried for longer distances.

IV. ECONOMIES IN THE USE OR COST OF WATER

37. The Economies Group met three times. The Group briefly reviewed the ways in which economies in the use or cost of water might be effected and decided to direct their attention to two points at which substantial savings appeared to be possible. These were waste prevention in public water undertakings and the conservation of water in industry.

38. The reports of the Ministry of Health Committee on Causes of Increase in Consumption of Water* and of the Research Committee of the Institution of Water Engineers on Economies in the Use of Water for Sanitation† were noted by the Group and their findings endorsed. The Research Committee of the Institution of Water Engineers recommended certain modifications in the design of domestic fittings and made other suggestions for reducing waste in the home, but changes of this nature can only be brought about gradually.

Waste Prevention in Public Water Undertakings

39. There are wide variations in the practice of waste prevention in the water industry. Some undertakers take no positive steps at all, while others pursue a vigorous policy of prevention, employing for the purpose such methods as extensive checks by means of waste-meters, physical inspection by waste inspectors and the free re-washering of taps. Leakage occurs in some degree in all distribution systems, the most common causes being failure of old mains owing to high water pressures, aggressive soil conditions and mining subsidence, and defective appliances and fittings. The problem has attracted the attention of the technical press and research organisations and its importance is recognised by the more efficient water undertakers. Indeed in some areas, as Figure 2 of Appendix II shows, the consumption of unmetered (mostly domestic) water per head of the population has fallen slightly since 1944, although standards of housing and of domestic hygiene have risen steadily.

40. Local conditions have a profound effect on the incidence of waste and the methods that can most successfully be adopted to reduce it. Thus in places where the sub-soil is an impervious clay, leaks are readily apparent on the surface. In chalk or other pervious ground, wastage underground may run at a high level unless active steps are taken to locate and check it.

41. The Group examined the techniques employed by some of the leading water undertakers, with particular reference to the use of waste-meters. Opinion on the value of waste-meters varied widely. Some undertakers use them over their whole system of water mains, while others, not less efficient, do not use them at all. Much again depends on local conditions and the existing level of consumption and in any event metering is usually supplemented by " sounding " (aural testing) and an intensive inspection service.

42. A number of undertakers stressed the importance of regulating water pressure. In districts where pressure is high, the burst pipe rate and unmetered consumption also tend to be high. The question of pressure is thus of importance when deciding which form of waste prevention would be most effective ; in flat districts, where pressures can be relatively low and uniform, waste tends to be much easier to control.

43. No accurate statistical assessment can be made of the amount of water saved by waste detection methods, because where a system has been in operation for a number of years it is difficult or impossible to say what consumption would be if such preventive measures had not been taken. The general opinion among undertakers however was that savings run at between 10 per cent. and 20 per cent. of the domestic consumption, or from 3 to 7 gallons per head per day. These figures are arrived at by observation

* 1949. Published by the British Waterworks Association, 34, Park Street, London, W.1.
† Journal of the Institution of Water Engineers, Vol. 8, No. 7, November, 1954.

of districts where waste detection has been suspended for a period and then resumed. The initial impact of waste detection methods can produce dramatic reductions.

44. All undertakers, whether using waste-meters or not, were convinced that their waste detection services were fully justified financially, although few attempted an estimate of costs and savings. One undertaker related the cost of the service to the cost of water that would otherwise have to be provided: the estimated saving was 2½ million gallons a day at a cost of £75 a million gallons, or £70,000 a year, which exceeded the cost of the waste prevention service. Another related the cost of the service to the number of inhabitants and the amount of water supplied, the cost working out at 9½d. a year per head of the population, or about 1d. a thousand gallons. The Group recognised however that as an undertaking becomes more efficient and waste declines, so it is more difficult and expensive to detect waste and a point is reached at which more intensive methods would not be worthwhile. No general indication could be given of where this point lies because local conditions vary so greatly but it was observed that most of the larger undertakers operating efficient services have unmetered consumptions of 24 to 26 gallons per head per day.

45. The Group concluded that a waste detection service, if it is devised to fit the circumstances of the area and is efficiently run, saves a large quantity of water and should more than pay for the cost of operation, and that all water undertakers ought to operate such a service.

Economies in Industry

46. Research in the United States and elsewhere has revealed a very wide divergence in the quantity of water used by different concerns in the manufacture of the same type of product, from which it appears that substantial savings can be made in the demand for water if all works in an industry can be brought nearer to the level of the most economical. The heaviest calls on water resources in England and Wales come from industry and are met to a considerable extent from sources controlled by industry itself rather than by public water undertakers. Accordingly, if it became necessary to reduce the calls on water resources in particular parts of the country, industrial economies might be essential.

47. At the invitation of the Economies Group, the Federation of British Industries submitted a memorandum on the use of water in industry and their representatives later gave oral evidence to the Group.

48. The concept of water as a valuable raw material of industry is comparatively new in this country, particularly where supplies are drawn from private sources and are not subject to the occasional restrictions imposed by public water undertakers in times of drought. Moreover, there is little or no financial inducement to economy because, so far as the Group could discover, in no industry does the cost of water amount to a significant proportion of the value of the product. Raising charges for metered water supplied by water undertakings would have little impact on the section of industry using public supplies and no bearing on the remainder which draws its water from private sources. Accordingly, information is not readily available on methods of industrial water conservation now in use or being developed in this country. With the collaboration of the Federation of

British Industries and individual manufacturers, an inquiry is now in progress into the industrial use of water from which it is hoped that an assessment can be made of the possibilities of saving water and the cost of so doing.

49. Suggestions have been made that industry should be encouraged to install water-saving apparatus by some special form of tax relief on the lines of the Investment Allowance or Fuel Efficiency Grants. The Investment Allowance has been withdrawn generally and is now given exceptionally in only three cases of special importance to the national economy—scientific research, ships and approved fuel saving equipment—and the Group did not consider that a strong case could be made in present circumstances for a further exception in the field of water supply.

50. In general the industrial consumer of water has so far been able to assume the availability of cheap and sufficient water supplies and water conservation has therefore not been a matter for concern. Part III of this report shows that area supplies are still adequate and that the total quantity of water will be enough for industrial needs as well as the needs of public water undertakers. This does not mean that there is no need for economy. Excessive abstraction from wells, for example, may deprive neighbouring wells of water or the inflow in some wells near the coast may become saline, As demand rises, so the cost of finding and piping water rises, because generally speaking the more easily and more cheaply developed sources are brought into use first. Rising demand may thus occasion expensive capital works in bringing in new sources.

51. The Group therefore considered that a national compaign to advise industrial water users in methods of industrial water conservation would be a valuable aid to economy. The problems of supply and demand could be described and explained and attention drawn to the results of using water wastefully. Advice might also be made available on the technical aspects either in booklet form or through advisory channels. The Federation of British Industries have offered to collaborate in such a campaign.

V. CONCLUSIONS AND RECOMMENDATIONS

52. We are in no doubt that the rainfall in England and Wales is sufficient to ensure an adequate supply of water to all parts of the country provided that proper means of conservation and distribution are developed to keep pace with the growing demand.

53. For the near future—up to 1965—we consider that the development schemes prepared by the public water undertakers will enable them to meet demands likely to be made on them. This is not to say that temporary or local shortages will not recur from time to time, quite apart from more general shortages in very dry years (when maximum domestic demand and minimum supply tend to coincide), or that industries seeking new sites will find abundant supplies in any place they care to choose; moreover, the estimates we have made necessarily assume that in any particular area the trend of consumption will follow approximately its present course, so that any significant deviation not foreseen at the present time could upset the balance. To make provision for full supply in conditions of extreme drought would require expenditure out of all proportion to the benefits

obtained, and we have considered it right to proceed on a basis of average demand and ordinary dry year (i.e. not extreme drought) supply.

54. We have had greater difficulty in assessing future requirements to be met from private sources because we have no complete census of such sources or of the total demand that must be, or is likely to be, met from them. The future pattern of supply will depend to some extent on the facilities offered to industry by public water undertakers, whose estimates make allowance for increasing demands from industry ; but until full information can be gathered—and we comment on this point below (paragraph 58)—forecasts are bound to be tentative. Nevertheless the estimates that it has been possible to make lead us to believe that in the shorter term the likely increase in demand can be met in each statistical area taken as a whole, although local difficulties may arise, particularly in districts relying on underground sources of supply.

55. For the more distant future—after 1965—we are of the opinion that there need be no shortage of water in any part of England and Wales provided that

(i) development schemes are prepared well in advance of demand ;

(ii) the necessary statutory powers and other authorisations are granted ;

(iii) capital investment is permitted on the requisite scale ;

(iv) the location of industries which require large quantities of water is regulated with the water supply situation in mind.

56. We emphasise that a satisfactory situation in the future must rest on the readiness of all concerned to regard water as a valuable commodity and to provide money and materials accordingly. We find some difficulty in predicting the requisite scale of investment by public water undertakers but trends suggest that the need is likely to be somewhat higher than the £35 million a year at present-day costs (see paragraph 36) forecast for the next few years because, among other reasons, new sources will be more difficult and costly to develop and water will have to be carried for longer distances.

57. The estimates make no allowance for water for agricultural irrigation. Development in this field is not at present predictable but it is clear from present trends that irrigation is capable of putting a severe strain on the water resources of those parts of the country least able to stand up to increased demand. The subject requires further investigation which we are now undertaking.

58. The statistical information at present available on water consumption and resources is incomplete, particularly as regards private supplies. Hydrological surveys by which comprehensive information could be obtained are long and expensive projects and there is little prospect of their being put in hand immediately on a country-wide scale. Nevertheless, in view of the contribution which such surveys could make to the study of supply and demand, we *recommend* that a start should be made in areas where the expected surplus of supply over demand is lowest.

59. We *recommend* that all undertakers should operate an adequate waste prevention service.

60. Little collated information is available on the economical use of water in industry. With the co-operation of the Federation of British Industries we

have initiated an investigation the results of whioh we hope to give in a later report.

61. We endorse the findings and recommendations of the Ministry of Health Committee on Causes of Increase in Consumption of Water and of the Research Committee of the Institution of Water Engineers on Economies in the Use of Water for Sanitation.

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62. The compilation of a report such as this has meant the collection of a great deal of statistical data and its collation, presentation and interpretation. Much enquiry has been necessitated over a wide field and intricate questions of detail have required investigation. We cannot end this report without recalling our appreciation of the work of the Secretary, Miss Petzsche, and the Assistant Secretary, Mr. Storr, and of the earlier work of Mr. Vaughan. Without their especial efforts we could not have covered the problems enumerated in this report nor been enabled to make the necessary assessments of the issues involved as in fact we have done. Whilst we would naturally have expected a high standard of secretarial efficiency we think that the officials who have served the Sub-Committee merit a special mention.

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M. E. PETZSCHE, *Secretary.*

J. W. STORR, *Assistant Secretary.*

STATISTICAL AREAS

(Based on Hydrometric Areas)

APPENDIX I

STATISTICAL AREAS

(See paragraph 4 of the report)

GROUPS OF HYDROMETRIC AREAS FOR STATISTICAL PURPOSES

(See accompanying map)

	Statistical areas in this report	*Reference numbers of the corresponding hydrometric areas in the Surface Water Year Book*
1.	Northumberland and Durham	22, 23, 24, 25
2.	Yorkshire	26, 27
3.	Trent	28
4.	Lincs., Welland and Nene	29, 30, 31, 32
5.	E. Anglia	33, 34, 35, 36
6.	Essex	37
7.	Thames and London	38, 39
8.	Kent and Sussex	40, 41
9.	Hants. and Dorset	42, 43, 44
10.	Cornwall and Devon	45, 46, 47, 48, 49, 50
11.	Bristol and Somerset	51, 52, 53
12.	Severn	54
13.	S. Wales	55, 56, 57, 58, 59
14.	S.W. Wales	60, 61, 62, 63
15.	N.W. Wales	64, 65, 66
16.	S. Lancs. and Cheshire	67, 68, 69
17.	N. Lancs. and Westmorland	70, 71, 72, 73, 74
18.	Cumberland	75, 76

APPENDIX II

STATISTICAL ANALYSIS OF SUPPLY AND DEMAND

1. Data supplied hy puhlic water undertakers are summarised by statistical areas (paragraph 4 of the report) in columns (2) to (5) of Figure 1. The figures have heen adjusted upwards on a population hasis to allow for a numher of small undertakers who did not complete, or only partly completed, the questionnaire. Columns (2) to (4), for 1955, sbow actual consumption; column (5), for 1965, is an estimate by the undertakers.

Column 6 shows the *survey supply* as defined in paragraph 14 of the report. In England and Wales water supply surveys by engineers of the Ministry of Health (later the Ministry of Housing and Local Government) were commenced in 1945 in co-operation with the public water undertakers and now cover almost the whole country. The surveys, which were directed to the requirements of water undertakers, were not generally speaking concerned witb self-supplied water from private sources. They attempted to determine the demand on undertakers for periods of twenty to thirty years from the date of the survey, according to area, with an adequate margin for safety and to suggest ways in which future needs could be met. In a few areas the survey material has heen supplemented by more recent information. The aim of the engineeers was to satisfy themselves that sufficient water could be found in an ordinary dry year to meet the future demand in each area, and no more. It is for this reason that the survey supply in certain areas—for example Cornwall and Devon—is very mucb less than the supply which could readily be made available if the appropriate engineering works were carried out; the survey supply is thus not an expression of the total water resources and *is in no sense a limiting figure.* The periods covered by the surveys end on various dates. The year 1965 has been taken as the common date (see column 6, Figure 1) for all areas to accord with the date of the future demand estimates.

2. Figure 2 shows for seven selected districts the past trends in terms of gallons per head of the population per day, ohtained by comparison of the averages of the years 1953–1955 with those of 1926–1928 and 1943–45. Figure 2 also throws some light on the progress of economy in the use of water, considered in Part IV of the report.

3. Unmetered consumption per head of the population actually served in the selected districts shows a slight overall increase since 1927 althougb the trend since 1944 has generally been downwards (the latter possibly being due to the growth of effective anti-waste measures). Tbe exceptionally rapid increase of 3½ per cent. per annum in Holland and Kesteven since 1944 may be due to the low level of consumption, which rose from only 13·5 gallons per bead per day in 1944 to 18 in 1955, whereas the 1944 consumption in the other selected districts varied between 22 and 35 gallons per head per day. A steep rise is in fact the common experience in rural areas wbere piped water is in course of heing introduced.

4. Metered consumption, on the other hand, shows an uninterrupted rise in all districts. From 1944 to 1955 consumption rose at the generally uniform rate of 3 per cent. per annum, with no suggestion of a decline.

5. It must not be overlooked that consumption in terms of gallons per head per day masks the rise in total consumption brought about by the rise in population. Country-wide data for metered and unmetered water, separately, are not available in sufficient detail to permit reliable numerical estimates to be made but

information is available for the seven selected districts and is displayed in diagram form in Figure 3.

6. Figure 4 shows the average increase per annum between 1955 and 1965 in metered and unmetered supplies, in terms of daily consumption per head of the population, forecast by public water undertakers. This table is given by administrative regions, as stated in paragraph 10 of the report, because the information supplied for 1965 was incomplete and did not lend itself to analysis by statistical areas. The table shows the estimated average annual increase per head per annum to be 2·4 per cent. for metered water, 1·1 per cent. for unmetered water and 1·5 per cent. overall. The figures for domestic consumption confirm the expectation that increases would be greater where present consumption is lower. Thus the average increase per annum for regions where consumption (in 1955) is 26 gallons per head or less is 1·6 per cent., that for regions where consumption is 32 gallons per head or more is 0·3 per cent., while the intermediate regions show 0·6 per cent. This position is reversed in metered consumption, where the higher the 1955 demand, the higher the indicated rate of increase. Thus regions where metered consumption is 16 gallons per head or less expect an average increase of 1·7 per cent. per year, those where it is 20 gallons per head or over expect an increase of 3·8 per cent. per year, while the figure for intermediate regions is 2·6 per cent.

7. Figure 5 shows the quantity of water used by the nationalised industries and six other major industries from sources other than public undertakers, e.g. private wells and river intakes (see the report, paragraphs 18 and 22). The figures have been adjusted as follows:—

(*a*) an addition of one third has been made to the returns received from the six industries, to make allowance for incomplete coverage;

(*b*) in four areas—Essex, Thames and London, Hampshire and Dorset, and Cumberland—information received from the industries has been supplemented by other information in the possession of the Ministry of Housing and Local Government.

8. Figure 5 should be read with paragraphs 17-22 of the report. *The figures do not represent, in any area, the total consumption supplied from private sources.*

BALANCE SHEET—SUPPLY AND DEMAND

Re-use of water

9. Water is frequently used more than once. Many industries for instance take water from a river and after using it for cooling or in processes discharge it, treated if necessary, back to the river; and this can be repeated many times along the river's course. The question of re-use, however, has proved far too intricate for detailed examination without a complete hydrological survey by which water could be traced through all stages in its passage to the sea.

A hydrological survey has recently been carried out in Wales by engineers of the Ministry of Housing and Local Government in the course of which information was obtained about the extent of re-use in both industrial and rural localities. The information suggested that the net demand varied from 56 per cent. to 76 per cent. of the gross demand, which means that the re-use of water reduced the gross demand by proportions varying between 44 per cent. and 24 per cent. The higher figure for re-use (44 per cent.) occurred in heavily industrialised South Wales, the lower (24 per cent.) in rural South West Wales. It thus appears that the lowest factor for re-use is likely to be in the neighbourhood of 25 per cent. and that a still lower figure, if applied to any of the statistical areas, would give an estimate of the net demand in that area with a sufficient allowance for error.

In estimating the net demand in all areas it was decided to apply a common re-use factor of 20 per cent., which is considered low enough to give a generous margin of safety. The net demand accordingly appears in the Balance Sheet, Figure 6, as 80 per cent. of the gross demand.

Computation of the mean water yield

10. Figure 7 shows the *mean water yield* and compares that yield with the survey supply (report, paragraphs 25 and 26). The yield of a catchment area may be defined as the sum of the surface run-off and the useful percolation; by useful is meant that part which is recoverable from wells and bores. In most areas of the country the greater part of the yield is surface run-off, though in permeable areas such as the Chalk and the Bunter Sandstone there are valuable contributions from the aquifers. The run-off may be determined by river gauging but gauging requires long periods of operation for reliable results and to form estimates for the whole country presupposes a more comprehensive network than is yet in existence. At present there is no accurate means of determining the useful percolation.

An alternative method is to estimate the yield from a knowledge of the rainfall and the losses arising from evaporation and transpiration. The losses to be expected can be computed in various ways, of which Penman's* formula for calculating evapo-transpiration is perhaps the best known and has given good results in use. Comparison of the results from this method with those from river gauging in areas where gauging data are available suggest that the two methods give approximately equal evaluations of the yield, provided that the areas are large enough to even out local differences due to geological and other variations. Penman's method has been used in calculating the mean yield shown in column 5 of Figure 7, where a rough Penman figure was subtracted from the general standard average rainfall for each statistical area. Complete accuracy is not claimed and it must be borne in mind that in permeable areas such as Thames and London a considerable part of the yield is in the aquifers and will not appear as surface run-off.

* Dr. H. L. Penman of the Rothamsted Experimental Station.

FIGURE 1

Public Water Undertakings—Demand and Supply in England and Wales

(million gallons per day)

Note	Statistical Area	Demand				Survey Supply
		Gross 1955			Gross 1965	
		Metered	Un-metered	Total	Total	
	(1)	(2)	(3)	(4)	(5)	(6)
* As explained in paragraphs 4 and 14 of the report, demand is computed on a basis of statistical areas, while supply is based on areas of water surveys carried out by the Ministry of Housing and Local Government. The survey areas are grouped and in certain cases divided so as to correspond as nearly as possible with statistical areas. The fit is generally good though nowhere exact; the large excess of supply shown in N.W. Wales and Cumberland, for instance, must be read against the slight apparent deficit in Lancashire.	1. Northumberland and Durham	51	59	110	156	207
	2. Yorkshire	79	111	190	234	298
	3. Trent	94	143	237	305	445
	4. Lincs., Welland and Nene ...	13	24	37	51	73
	5. East Anglia	16	36	52	66	71
	6. Essex	19	32	51	66	90
	7. Thames and London ...	166	326	492	562	625
	8. Kent and Sussex	27	66	93	119	122
	9. Hants and Dorset	27	42	69	87	135
	10. Cornwall and Devon ...	17	36	53	60	78
	11. Bristol and Somerset ...	19	36	55	61	66
	12. Severn	18	34	52	68	89
	13 & 14. S. and S.W. Wales ...	38	70	108	142	176
	15. N.W. Wales	3	10	13	15	84*
	16. S. Lancs. and Cheshire ...	113	150	263	317	} 383*
	17. N. Lancs. and Westmorland...	27	48	75	98	
	18. Cumberland	3	5	8	10	43*
	TOTAL	730	1,228	1,958	2,417	2,985

FIGURE 2

CONSUMPTION AND TRENDS IN SEVEN SELECTED DISTRICTS IN TERMS OF GALLONS PER HEAD PER DAY (See also figure 3)

Public Water Undertakers only

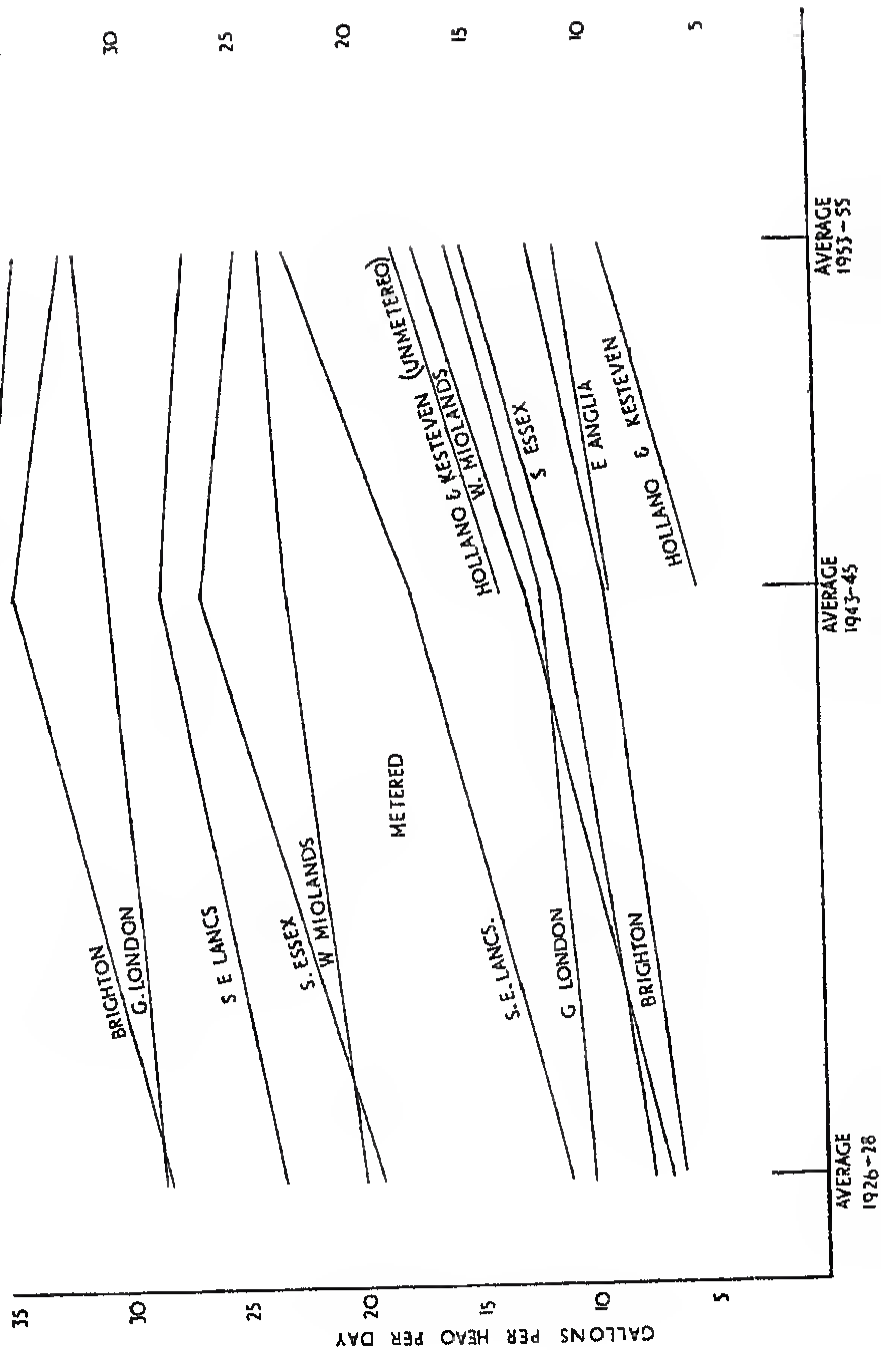

FIGURE 3

TOTAL CONSUMPTION AND TRENDS IN SEVEN SELECTED DISTRICTS (See also Figure 2)

Million Gallons Per Day

Public Water Undertakers only

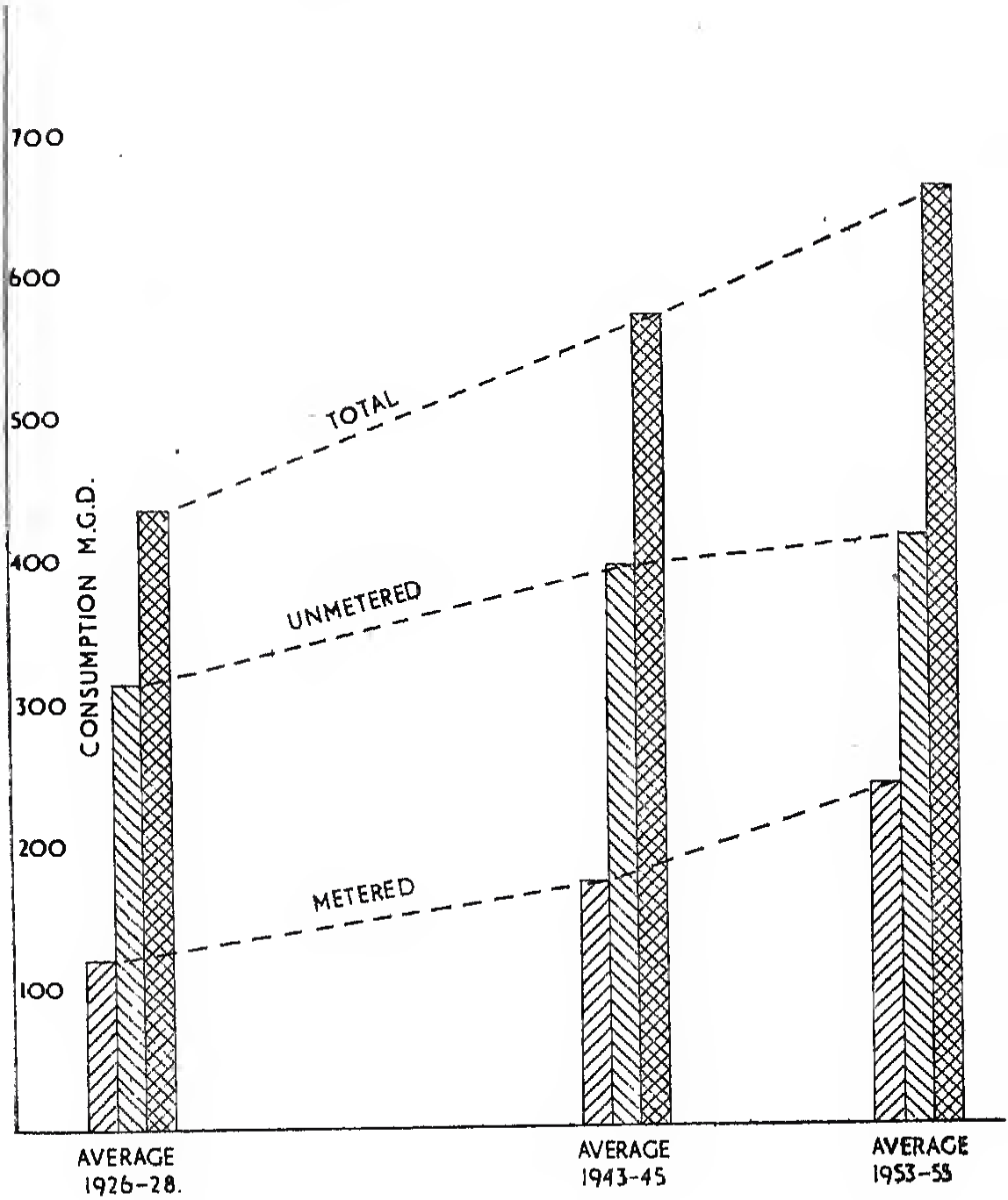

FIGURE 4

Estimated Daily Consumption of Water per Head: 1955 and 1965
Public Water Undertakings only

Administrative Region	Metered			Unmetered			Total		
	1955 (gallons) (1)	1965 (gallons) (2)	Per cent. increase per year (3)	1955 (gallons) (4)	1965 (gallons) (5)	Per cent. increase per year (6)	1955 (gallons) (7)	1965 (gallons) (8)	Per cent. increase per year (9)
1. Northern	20	30	5·0	24	29	2·1	44	59	3·4
2. E. and W. Riding ...	18	22	2·2	26	30	1·5	44	52	1·8
3. N. Midlands	14	17	2·2	24	28	1·8	38	45	1·9
4. Eastern	14	17	2·2	26	29	1·1	40	46	1·5
5. London and S. Eastern	16	18	1·25	31	32	0·3	47	50	0·7
6. Southern	18	21	1·7	30	32	0·7	48	53	1·0
7. S. Western	12	13	0·8	32	33	0·3	44	46	0·5
8. Wales	18	25	3·9	36	37	0·3	54	62	1·5
9. Midlands	16	19	1·9	26	30	1·5	42	49	1·7
10. N. Western	22	28	2·7	29	31	0·7	51	59	1·6
England and Wales ...	17	21	2·4	28	31	1·1	45	52	1·5

FIGURE 5

Industrial Water for Selected Industries from Private Sources

(See paragraphs 17–22 of the Report and sections 7 and 8, Appendix II)

Statistical Area (1)	Demand 1955 (million gallons per day) (2)	Assumed Demand 1965 = Col. (2) + 25 per cent. (million gallons per day) (3)
1. Northumberland and Durham	22	27
2. Yorkshire	166	207
3. Trent	185	231
4. Lincs., Welland and Nene ...	21	26
5. E. Anglia	10	12
6. Essex	20	25
7. Thames and London	100	125
8. Kent and Sussex	127	159
9. Hants. and Dorset	10	12
10. Cornwall and Devon	11	14
11. Bristol and Somerset	46	57
12. Severn	15	19
13. and 14. S. and S.W. Wales ...	367	459
15. N.W. Wales	16	20
16. S. Lancs. and Cheshire ...	485	606
17. N. Lancs. and Westmorland ...	47	59
18. Cumberland	20	25
Total	1,668	2,083

FIGURE 6

Balance Sheet of Supply and Demand (Public and Private) in 1965

(See paragraphs 23 and 24 of the Report and section 9, Appendix II)
(Million Gallons Per Day)

Notes	Statistical Area (1)	Demand 1965 Gross (2)	Demand 1965 Net (Col. 2 × 80 per cent.) (3)	Supply 1965 Survey Supply plus Private Sources (4)
(*a*) This table should be regarded as giving approximate figures for the purpose of comparison. It does not show the total demand for water or the total available supply. The compilation of the figures and their limitations are described in Part III of the Report and in Appendix II.	1. Northumberland and Durham	183	146	229
(*b*) Column (2) is the sum of the figures in Fig. 1, column (5) and Fig. 5, column (3).	2. Yorkshire	441	353	464
(*c*) Column (3): the proportion of 80 per cent. is introduced to allow for re-use (see section 9). Both columns (2) and (3) are based on statistical areas.	3. Trent	536	429	630
(*d*) Column (4) is the survey supply (Fig. 1, column 6) plus private sources (Fig. 5, column 2). As explained in paragraphs 4 and 14 of the report, demand is computed on a basis of statistical areas while supply is based on areas of water surveys carried out by the Ministry of Housing and Local Government. The survey areas are grouped and in certain cases divided so as to correspond as nearly as possible with statistical areas.	4. Lincs., Welland and Nene ...	77	62	94
	5. East Anglia	78	62	81
	6. Essex	91	73	110
	7. Thames and London	687	550	725
	8. Kent and Sussex	278	222	249
	9. Hants. and Dorset	99	79	145
	10. Cornwall and Devon	74	59	89
	11. Bristol and Somerset	118	94	112
	12. Severn	87	70	104
	13 & 14. S. and S.W. Wales ...	601	481	543
	15. N.W. Wales	35	28	100
	16. S. Lancs. and Cheshire ...	923	738	915
	17. N. Lancs. and Westmorland	157 } 1,080	126 } 864	
(*e*) No allowance has been made for the transfer of water from one statistical area to another; thus the Trent supply (621 m.g.d.) includes water taken from the South Wales statistical area to Birmingham.	18. Cumberland	35	28	63
	TOTAL	4,500	3,600	4,653

FIGURE 7

1965 Supply and the Mean Water Yield
Comparative Development of Resources

Notes	Statistical Area	Population 1957 (Million)	Area (1,000 Sq. Miles)	Average Annual Rainfall (Inches)	Mean Yield Average Year (million gallons per day)	Supply 1965 (million gallons per day)	Ratio of Supply to Mean Yield (per cent.)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Column (2)—Registrar General's Mid-Year Estimates, 1957. Column (3)—Approximate areas taken from O.S. Map 1870, Scale 10 miles/inch, River Catchment Basins. Column (4)—Approximate Rainfall by Surface Water Survey Centre checked by Meteorological Office. Column (5)—Estimated by Surface Water Survey Centre (see section 10, Appendix II). Column (7)—Figures reflect the *relative* difficulty of increasing the supply beyond that envisaged in 1965: a high figure probably indicates greater difficulty than a low one but not necessarily.	1. Northumberland and Durham	2·613	3·5	33	2,800	229	8
	2. Yorkshire	4·378	5·2	32	3,500	464	13
	3. Trent	5·239	4·1	28	1,900	630	33
	4. Lincs., Welland and Nene ...	1·104	3·5	24	1,200	94	8
	5. East Anglia	1·739	5·7	24	1,700	81	5
	6. Essex	1·655	1·2	23	300	110	36
	7. Thames and London ...	10·184	4·7	28	1,800	725	40
	8. Kent and Sussex	2·460	3·0	29	1,300	249	19
	9. Hants. and Dorset	1·594	2·9	33	1,600	145	9
	10. Cornwall and Devon ...	1·157	4·0	43	4,000	89	2
	11. Bristol and Somerset ...	1·258	2·1	33	1,200	112	9
	12. Severn	1·983	4·4	32	2,100	104	5
	13. S. Wales	1·933	3·4	48	} 6,400	543	8
	14. S.W. Wales	·218	2·0	50			
	15. N.W. Wales	·650	2·7	52	3,600	100	3
	16. S. Lancs. and Cheshire ...	4·897	1·7	35	1,200	} 915	18
	17. N. Lancs. and Westmorland...	1·639	2·3	58	3,900		
	18. Cumberland	·204	1·5	53	2,300	63	3
	TOTAL	44·9	57·9	35	40,800	4,653	11

APPENDIX III

LIST OF AUTHORITIES AND ORGANISATIONS FROM WHICH EVIDENCE WAS RECEIVED

1. British Paper and Board Industry Research Association.
2. Federation of British Industries, and Trade Associations.
3. Association of Drainage Authorities.
4. River Boards' Association.
5. British Waterworks Association.
6. Public Water Undertakers.
7. British Transport Commission.
8. Central Electricity Generating Board.
9. Gas Council.
10. National Coal Board.
11. Surface Water Survey Centre.
12. Ministry of Agriculture, Fisheries and Food.
13. Ministry of Housing and Local Government.
14. Ministry of Power.
15. Department of Scientific and Industrial Research.

Printed and published in Great Britain by
HER MAJESTY'S STATIONERY OFFICE

(87504) Wt. 4004—1516 K40 2/59 D.L.

S.O. Code No. 75-65